

Creating Acquisition Insight Through Measurement

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May 2, 2006

Acknowledgements

This work would not have been possible without assistance from the following:

- **Funding source**

- ❖ Mission-Oriented Investigation and Experimentation (MOIE)
Research Program (Software Acquisition Task)

- **Sponsor**

- ❖ Michael Zambrana, USAF Space and Missile Systems Center (SMC), Directorate of Systems Engineering

Outline

- **Background**
 - ❖ History of the “Bell Ringing” Initiative
 - ❖ Overview of the Framework for Software Acquisition Early Warning Indicators
- **The Acquisition Program Office**
 - ❖ Overview and characteristics
 - ❖ Metrics for monitoring its own work
 - ❖ Metrics for understanding the constraints on the contractor
 - ❖ Selecting a balanced metrics set
- **Conclusions**

History of the “Bell-Ringing” Initiative

- **Beginning in 1999, failures in high-profile acquisition reform programs began to emerge at SMC**
 - ❖ Performance deficiencies, extensive software defects
 - ❖ Large, unanticipated cost and schedule overruns
- **Extent and severity of software-related problems were not understood until late in the development life cycle**
- **One SMC System Program Director expressed the desire to have a set of “bell-ringing criteria”**
 - ❖ Early warning indicators of actual or potential problems in one or more factors that influence success of software-intensive system acquisitions
 - ❖ Signal the need for additional management attention to the influencing factors

Aerospace “Bell-Ringing” Research

- Aerospace began a research project to develop a comprehensive set of “bell-ringing criteria”
- Factors adversely influencing the success of software-intensive system acquisition were determined to extend far beyond those controlled by the contractor’s software development teams
- Research project first phase: Define a **Framework** for identifying and classifying these factors
 - ❖ Framework to define the relationships and interactions of the factors
 - ❖ Framework to include quantitative indicators derived from the factors
 - These indicators to provide foundation for satisfying the realistic information needs of the acquisition manager

The Approach for Defining the Framework for Software Acquisition Early Warning Indicators

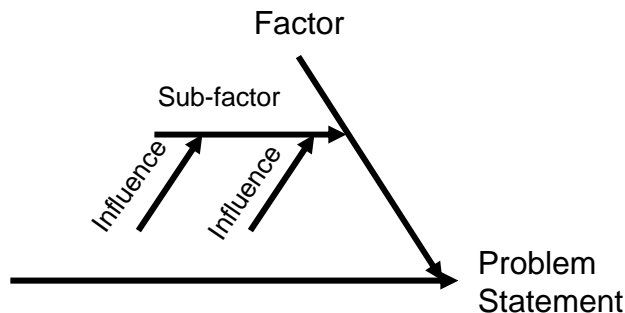
Problem:

- Needed a simple way to model systemic influences and factors
- Needed to be able to express Cause (influence) and Effect (factors)
- Needed an intuitive information presentation method

Approach:

- Ishikawa Diagrams selected for
 - Ease of use
 - Automated tools
 - Low training needs

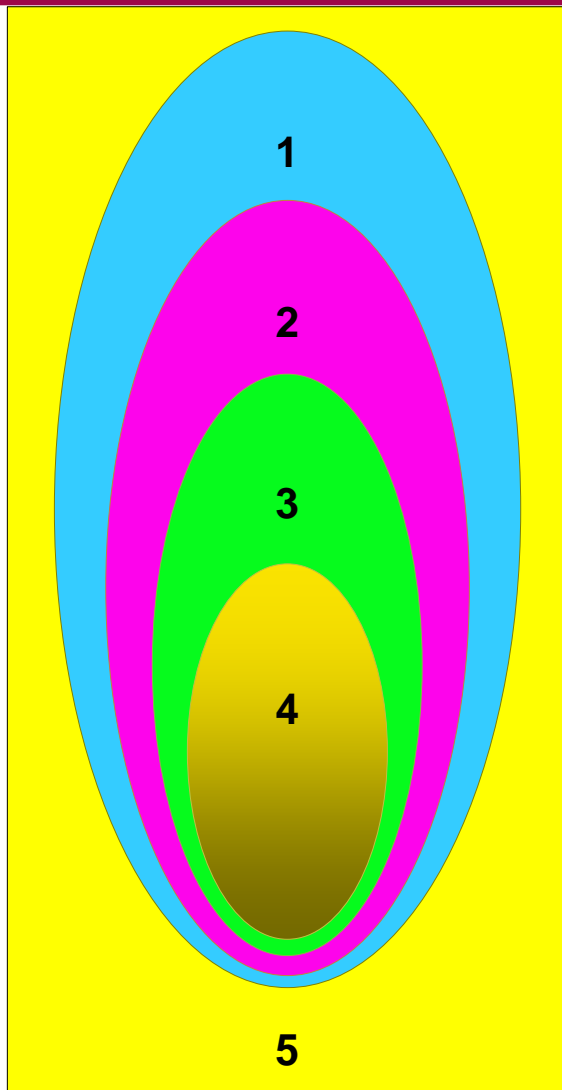
Example:



Definitions:

- **Problem Statement** - A statement of the problem—usually provided in terms of a necessary improvement
- **Factor** - Possible causes of the problem
- **Sub-factor** - The lower level factors of the subset problem
- **Influence** - Measurable feature of the factor or sub-factor

The Framework for Acquisition Early Warning Indicators



- 1. Acquisition Environment** – Influences from acquisition-related organizations external to the SPO, including acquisition management, user/operator, independent test and certification, interfacing system, support, and Government provider (e.g., GOTS, GFE/GFI, facilities) organizations
- 2. Acquisition Program Office** – Influences from the SPO itself, including everyone from the SPO director down through the lowest level personnel, plus Aerospace, other FFRDCs and SETA contractors that support the SPO
- 3. Contractor Environment** – Influences from contractor team organizations external to contractor team's engineering organizations, including corporate and program management, quality assurance/software quality assurance, contracts, scheduling, and organizational process improvement groups
- 4. Product Development** – Influences from contractor team engineering organizations, including systems engineering, software engineering, specialty engineering, test organizations, and configuration management
- 5. Unification** – Influences from the interrelationships among the first four factors, such as customer satisfaction, communication and agreements

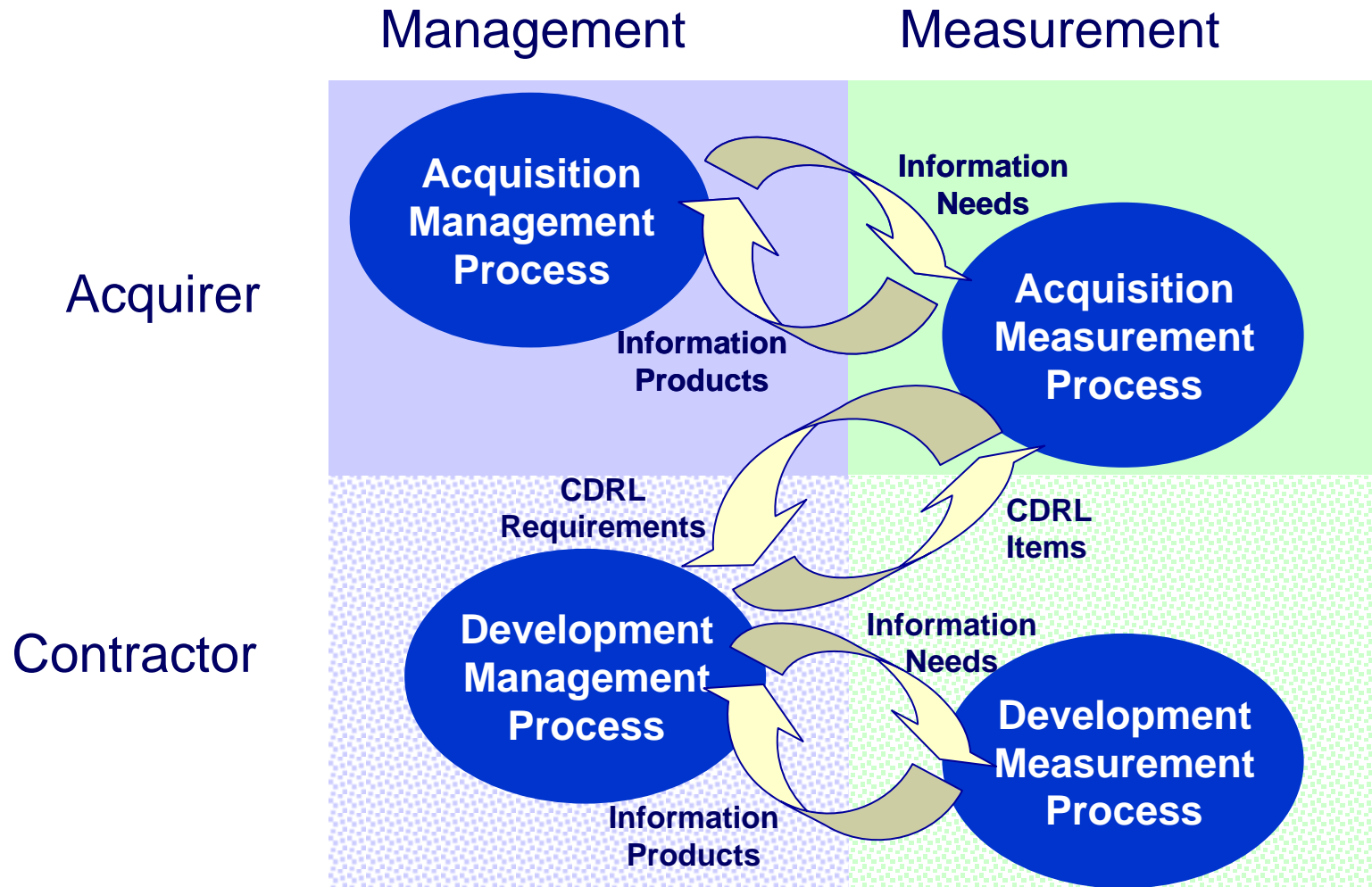
The Unique Role of the SPO



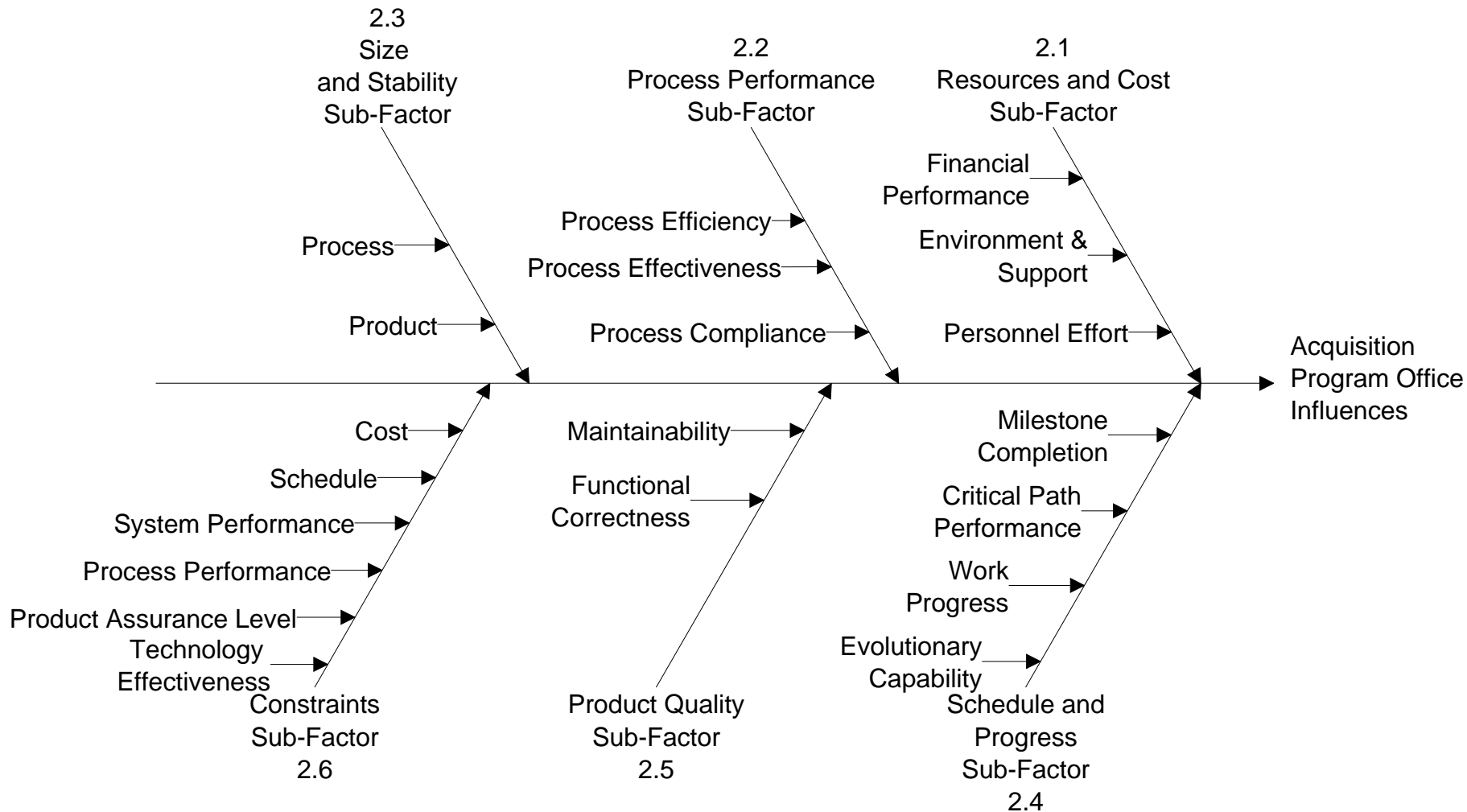
Example Products of the Acquisition Program Office

- **System Requirements**
 - ❖ Draft System Specification (DSS), Technical Requirements Document (TRD), System Performance Specification (SPS)
- **Interface Requirements**
 - ❖ Interface Requirements Specification (IRS), Interface Control Document (ICD)
- **Acquisition Products**
 - ❖ Request for Proposal (RFP) Package
 - ❖ Acquisition Strategy Briefing
 - ❖ Program Milestone/Key Decision Point (KDP) Briefing, Integrated Program Summary (IPS)
- **Test and Evaluation (T&E) Products**
 - ❖ Test and Evaluation Master Plan (TEMP)
- **Cost and Schedule Products**
 - ❖ Cost Analysis Requirements Document (CARD)
 - ❖ Program Schedule
- **Other Products**
 - ❖ Trade Studies (e.g., Architecture Studies)
 - ❖ Management Reports
 - ❖ Processes, Training

Software Measurement and Acquisition Management



Acquisition Program Office Subfactors and Influences



Acquisition Program Office Subfactors

- **Resources and Cost** - Included are the program-specific personnel resources responsible for performing the work within this factor and the Acquisition Program Office infrastructure, facilities and other resources required to execute the program
- **Process Performance** - processes used by the organizations and functions in the Acquisition Program Office factor to perform the work and produce the products for which they are responsible
- **Size and Stability** - addresses the size and stability of the processes used and of the products produced by the organizations and functions in the Acquisition Program Office factor
- **Schedule and Progress** - addresses the schedule and progress of the work performed by the organizations and functions in the Acquisition Program Office factor
- **Product Quality** - addresses the quality of the products produced by the organizations and functions in the Acquisition Program Office factor
- **Constraints** - addresses the various constraints imposed by the organizations and functions in the Acquisition Program Office factor on all types of work (engineering, management, support) being performed by the contractor on the program

Acquisition Program Office Influences and Example Metrics - 1

Subfactor	Influence (Issue)	Metric
Resources & Cost	Personnel Effort	Staff Level
		Effort
		Staff Turnover
		Overload
		Unplanned Tasking
	Financial Performance	Budget
		Cost
	Environment & Support	Quantity Needed/Available
		Time Needed/Available
		Fidelity & Quality of Resources
		Time Used

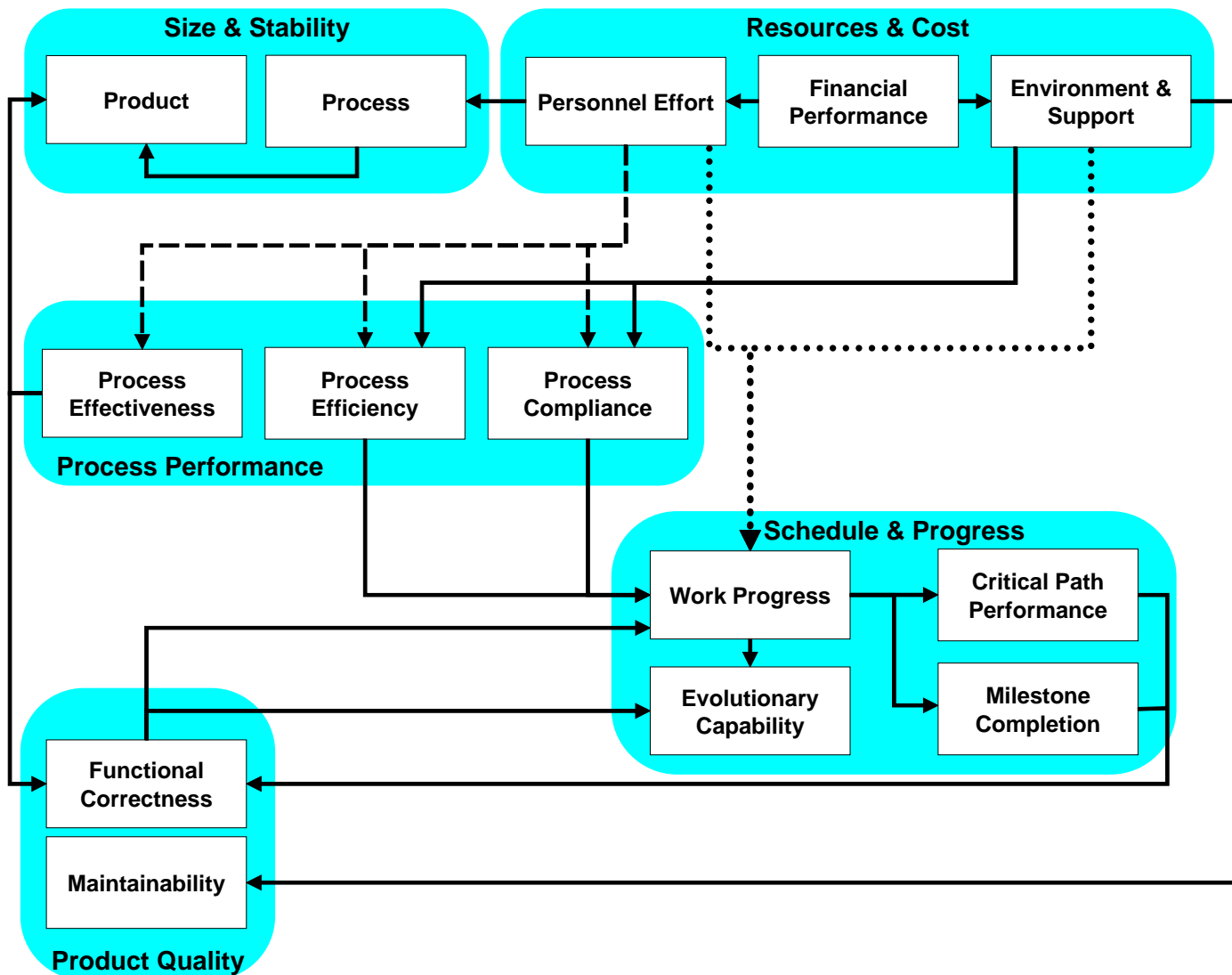
Acquisition Program Office Influences and Example Metrics - 2

Subfactor	Influence (Issue)	Metric
Process Performance	Process Compliance	Reference Maturity Profile
		Process Audit Findings
	Process Efficiency	Productivity
		Cycle Time
	Process Effectiveness	Defects Contained
		Defects Escaped
		Rework Effort
		Rework Components
Size and Stability	Processes	Process Size
		Process Changes
	Products	Product Size
		Product Changes

Acquisition Program Office Influences and Example Metrics - 3

Subfactor	Influence (Issue)	Metric
Schedule and Progress	Milestone Completion	Milestone Dates
		Schedule Compression Ratio
	Critical Path Performance	Slack Time
	Work Progress	Requirements Traced/Untraced
		Action Items Opened/Closed
		Change Requests Opened/Closed
	Evolutionary Capability	Capabilities Fielded
		Interfaces Integrated
Product Quality	Maintainability	Complexity
	Functional Correctness	Defects
		Age of Defects
		Completeness
		Estimating Accuracy

Interaction among Acquisition Program Office Subfactors and Influences



Acquisition Program Office Metrics: Cost and Schedule Performance Indexes

Compare actual work accomplished on a project to the original plan, and track cost and schedule performance for the work completed

- **ANALYSIS MODEL –**

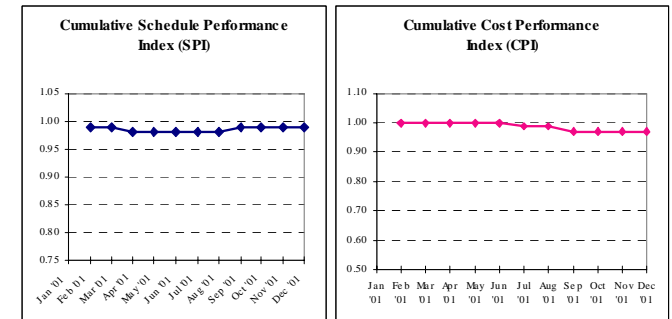
- CPI and SPI are plotted over time to show trends.
- Indices greater than 1.0 indicate under cost (CPI) and ahead of schedule (SPI).
- Indices less than 1.0 indicate over cost (CPI) and behind schedule (SPI).

- **DECISION CRITERIA –**

- CPI and SPI at the cumulative level are an indication of the health of the program.
- Values less than 0.9 are an indication that there are problems that should be addressed.
- The overall trends should be reviewed. Several months of declining values are an indicator that there are issues that should be addressed.

SPO SPI and CPI

Activity	Year		2001											
	Month		Jan '01	Feb '01	Mar '01	Apr '01	May '01	Jun '01	Jul '01	Aug '01	Sep '01	Oct '01	Nov '01	Dec '01
Cumulative SPI				0.99	0.99	0.98	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99
Monthly SPI				1.00	0.90	0.61	0.76	0.76	0.57	0.75	0.93	0.93	1.00	1.00
Cumulative CPI				1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.97	0.97	0.97	0.97
Monthly CPI				1.13	1.26	0.97	1.15	0.96	0.82	0.82	0.69	0.69	0.70	0.70



Framework

Factor: Acquisition Program Office

Subfactor: Resources and Cost

Influence: Financial Performance

Metric: Cost

Acquisition Program Office Metric: Unplanned Tasking Effort

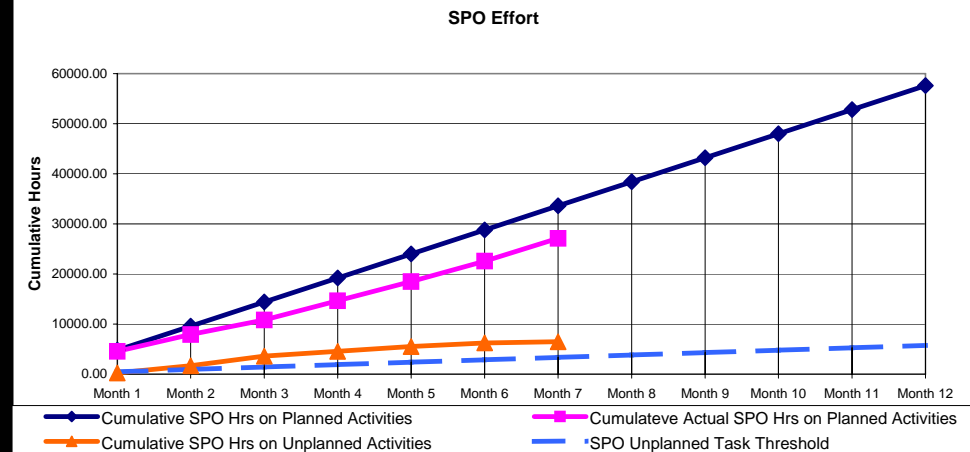
Compare actual effort against the original plan, and track variance due to unplanned tasking

- **ANALYSIS MODEL –**

- Cumulative effort (planned staff-hours, actual staff-hours on planned work and on unplanned tasking) is plotted over time to show trends.
- The actual effort spent on unplanned tasking should stay within the decision criteria.

- **DECISION CRITERIA –**

- Effort at the cumulative level is an indication of the health of the program.
- More than 10% of planned effort spent on unplanned tasking indicates a dilution of effort on planned program tasks.
- The overall trends should be reviewed. An adverse trend over 3 months is an indicator that there are issues that should be addressed.



Framework

Factor: Acquisition Program Office

Subfactor: Resources and Cost

Influence: Personnel Effort

Metric: Unplanned Tasking

Acquisition Program Office Metric: Action Items Opened/Closed

Understand the magnitude of the impact of the SPO work backlog
by tracking action item status

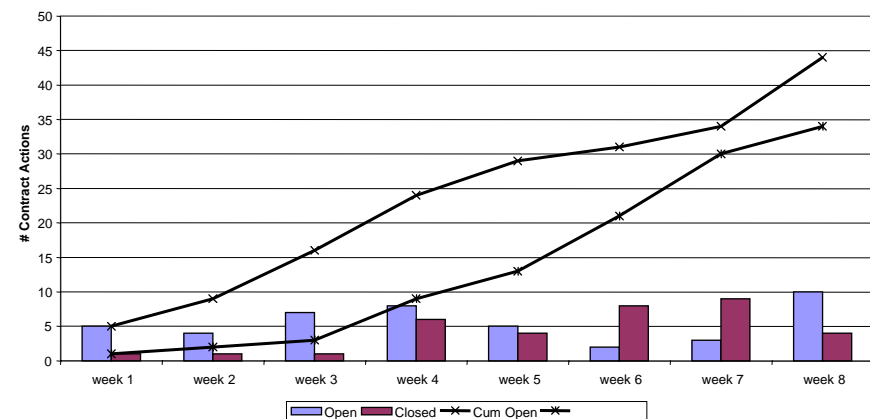
- **ANALYSIS MODEL –**

- Action items are plotted over time to show trends
- Bar chart shows the magnitude of the action items opened and closed each week; line chart indicates the cumulative open and closed action items from week to week
- Action item closure rates should remain consistent over course of program in order to prevent SPO communication backlog

- **DECISION CRITERIA –**

- Open action item buildup is an indication of management overload, leading to a lack of communication with the contractor.
- A closure rate of less than 85% is generally an indicator of SPO overload.
- Consistent information exchange backlog leads to continual discovery and rediscovery of the same issues.

SPO Action Items Opened/Closed



Framework

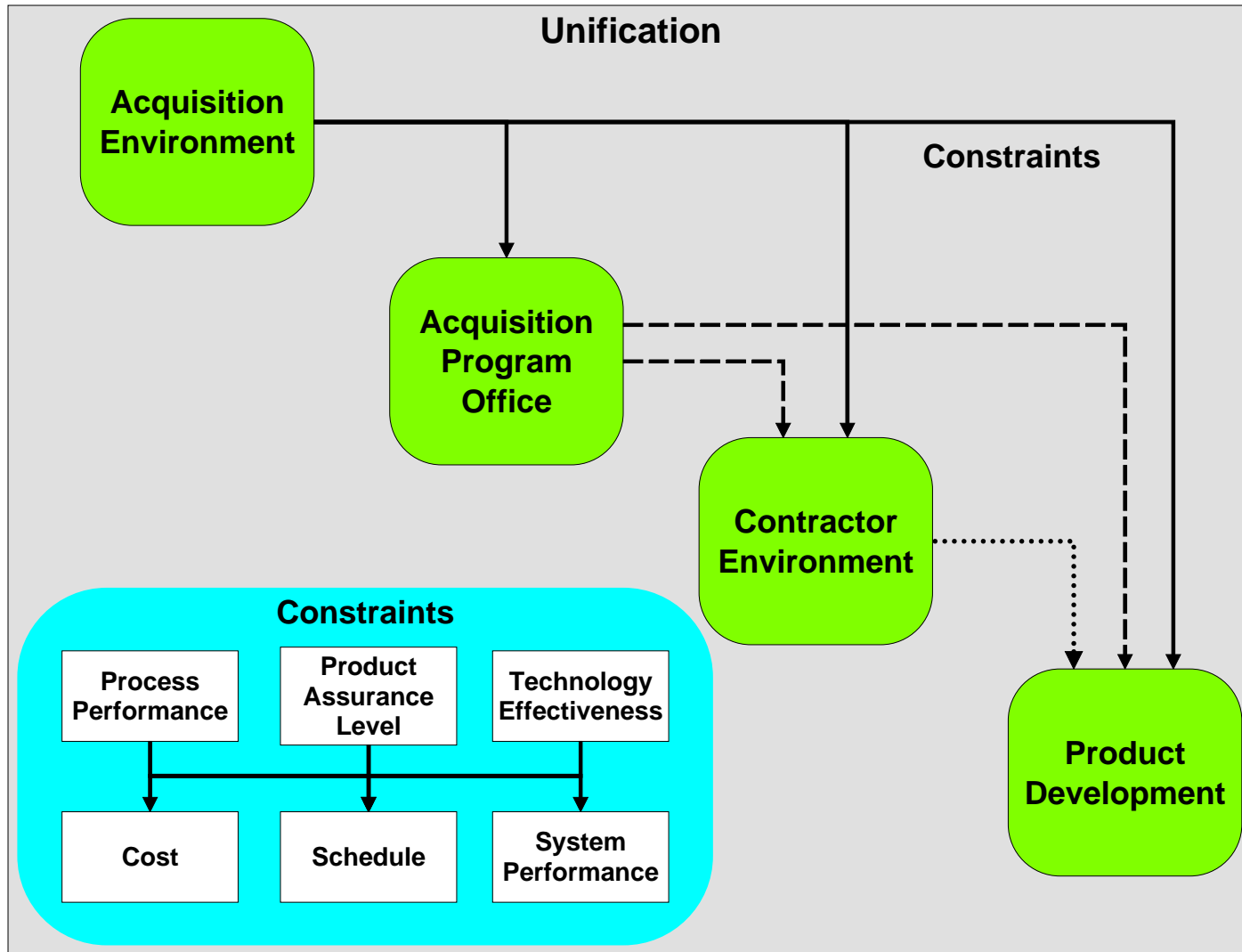
Factor: Acquisition Program Office

Subfactor: Schedule and Progress

Influence: Work Progress

Metric: Action Items Open/Closed

The Reality of Contracting Constraints



Acquisition Program Office Constraints

Subfactor - 1

Influence (Issue)	Example Metrics
Cost	Contract Dollars Profile
	Fiscal Year Dollar Profile
	Volatility
Schedule	Fixed Milestone Dates
	Volatility
System Performance	Timing
	Accuracy
	Reliability/Availability
	Maintainability
	Program Specific QPRs
	Volatility
Process Performance	CMM/CMMI Goals
	Processes
	Volatility

Acquisition Program Office Constraints

Subfactor - 2

Influence (Issue)	Example Metrics
Product Assurance Level	Safety
	Security
	IV&V
	Quality
	Volatility
Technology Effectiveness	Suitability
	Readiness (TRL)
	Volatility

Selecting a Balanced Set of Acquisition Program Office Metrics

- **Balance the metrics across the subfactors**
 - ❖ Resources and Cost
 - ❖ Process Performance
 - ❖ Size and Stability
 - ❖ Schedule and Progress
 - ❖ Product Quality
 - ❖ Constraints
- **Focus on:**
 - ❖ Areas of highest risk, and
 - ❖ Areas where meeting process improvement goals will provide the greatest benefit
- **Keep the number of Acquisition Program Office metrics small, especially initially**
 - ❖ Target 7 to 11 metrics at most
- **Techniques used for selecting development metrics are useful here as well (e.g., GQM, PSM)**

Example: Selecting a Balanced Set of Acquisition Program Office Metrics

- **Metrics for managing the work of the Acquisition Program Office**
 1. How is unplanned tasking affecting the program work? (Resources and Cost)
 2. Is the actual cost of the Acquisition Program Office work tracking to the plan? (Resources and Cost)
 3. What is the cycle time for responding to contractor requests for information? (Process Performance)
 4. How stable is the system requirements specification? (Size and Stability)
 5. What is the critical path for the Acquisition Program Office's integration tasks? (Schedule and Progress)
 6. Is there a growing backlog of action items for which the Acquisition Program Office is responsible? (Schedule and Progress)
 7. How many defects have been identified in the released system requirements specification? (Product Quality)
- **Metrics for understanding the driving constraints being placed on the contractor**
 8. What is the readiness level of the critical technology being imposed?
 9. How volatile are the critical system performance parameters?

Conclusions

- **This research effort has defined an integrated framework for software acquisition early warning indicators**
 - ❖ Includes all participants in the acquisition and development environment, not just the contractor's product development team
 - ❖ Addresses the full program life cycle
 - ❖ Aids in understanding the impact on mission success of all of the factors
 - ❖ Aids in identifying where corrective action is needed
- **The framework provides a specific measurement perspective for the work of the Acquisition Program Office**
 - ❖ Provides measures for the influences of the Acquisition Program Office, including its product and process performance
 - ❖ Provides a basis for measurement in an Acquisition Program Office process improvement effort

Past SSTC Papers on This Research

- L. A. Abelson, R. J. Adams and S. Eslinger, “A Framework for Software Acquisition Early Warning Indicators: Beyond Development Metrics,” Software Technology Conference 2003, 1 May 2003.
- L. A. Abelson, R. J. Adams and S. Eslinger, “Software Acquisition Failure Profiles: When a Single Metric Just Won’t Do,” Systems and Software Technology Conference 2004, 20 April 2004.
- L. A. Abelson, R. J. Adams and S. Eslinger, “Software Acquisition Failure Profiles: Recognizing Common Patterns of Software Acquisition Failure,” Systems and Software Technology Conference 2005, 19 April 2005.

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Acronyms

CARD	Cost Analysis Requirements Document
CDRL	Contract Requirements Data List
CPI	Cost Performance Index
DSS	Draft System Specification
FFRDC	Federally Funded Research and Development Center
GFE	Government Furnished Equipment
GFI	Government Furnished Information
GOTS	Government Off the Shelf
GQM	Goal-Question-Metric
ICD	Interface Control Document
IPS	Integrated Program Summary
IRS	Interface Requirements Specification
KDP	Key Decision Point
MOIE	Mission Oriented Investigation and Experimentation
QPR	Quantitative Performance Requirement
PSM	Practical Software and System Measurement
RFP	Request for Proposal
SETA	Systems Engineering and Technical Assistance
SMC	Space and Missile Systems Center
SPI	Schedule Performance Index
SPO	System Program Office
SPS	System Performance Specification
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
TRD	Technical Requirements Document
TRL	Technology Readiness Level
USAF	United States Air Force